Integrating the K2 and Transverters Using the KRC2 Band Decoder and Transverter Interface K60XV

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Introduction

I desired to build a K2 based high performance portable station that would serve my VHF, UHF, and microwave needs, but preserve the full HF capability. Additionally I wanted it to be simple to operate requiring no more than pressing the K2's BAND UP and BAND DOWN buttons to select the right band's equipment lineup. If that was not enough, I wanted to be able to lift this system off my desk and drop into my truck for a VHF or microwave contest in less than 10 minutes. Just add the antennas on the truck (which are generally pre-mounted to removable poles) and I am off to a remote mountain top somewhere.

This paper is an update that reflects operational and design changes since the publishing of my original paper in April 2004. In the original paper I had requirements for split 2M IF to work with my home station PA and tower T/R switches. I have since dedicated other radios to that purpose allowing me to further simplify this project. Also this year Elecraft released their 432MHz transverter which I have now incorporated. While I was on a roll, I swapped out the pair of 24V SMA 144MHZ IF switches for a single 12V SMA switch, changed the 144, 903, and 1296MHz transverters to common 144MHz IF configuration, reduced the cable count, and finally improved the rear connector bulkhead with all bands available on the back panel. Since most of the surplus amps do not have built in T/R switches I mounted T/R switches behind the panel for some bands, and TX drive connectors brought out to allow fast insertion of external power amplifiers.

My station is built to cover the following frequency bands:

1. 160M through 10M using my QRP K2 with the KAT2 and battery
2. 144MHz, 222MHz, 432MHz, 903MHz, 1296MHz
3. Possible expansion for 50MHz later. I already had 6M at 100W adequately covered with other gear so my priority was on other bands for now. I have saved space for one more transverter in the cabinet.

I could have optimized the 2M setup to just drive transverters since I had several other radios with 2M capability; however I wanted to take advantage of the K2's crunch proof front end. During VHF contests when I am on a

mountain top and other contest rovers are line of sight from me, and kilowatt contest stations are running in the valleys below me, my other rigs caved in with front end overload and operating on 2M was useless for a period of time. With the K2, that has changed.

Requirements

Here is a list of the general requirements that I needed to satisfy:

1. The K2 is the IF and HF radio anchoring my setup. An IF radio means that the K2 28MHz output is used to drive a transverter to put me on a VHF or microwave band and preserve the features and performance of my K2. It is small enough to conserve weight and space.
2. All relay switching, antenna selection, and transverter enabling would need to be coordinated through the radio interfaces by operating the K2 BAND+ and BAND- buttons.
3. For portability, speed of relocation, and reliability, mount everything in one compact box. It would be pre-tested. It needed to look nice and match my home office furniture well.
4. All power distribution would use Power Pole connectors where possible. The house and the truck are equipped with distribution this way. I use RIGRunner panels in the box and at home and some standard heavy red/black wire jumpers. For 24VDC power I also use the Power Poles, but they are oriented 90 degrees from the 12VDC configuration so I cannot mix them up, and recently started using back and white colored shells also. Most of my amps are 24VDC commercial surplus. I use a 29amp 24VDC power supply at home, and a 12 to 24V 25A DC-DC converter when mobile.
5. Antenna connectors must be easy to get at for rapid hookup.
6. Standardize on Type N for antenna connections on all bands 144MHz and higher.
7. My external jumpers are all N to N reducing the chance of not having the right kind of coax jumper handy and reducing my jumper inventory.
8. Internal jumper connections use RG-142 and RG-316 Teflon coax using SMA, BNC and N connectors to match the equipment as necessary.

Digging a little deeper here are some more detailed requirements:

1. For 144MHz SSB/CW
    a. Use the XV144 transverter. This will be used with or without amplifiers.
    b. 80W amplifier mounted in the same box as the radios, with external PTT on the back panel. A 10W input model was chosen to better match the 3W drive level needs of the 903 and 1296MHz

transverters. The K2 power control settings for each band are used to limit the max power and not overdrive the transverters.

2. 222MHz SSB/CW using the XV222 transverter driving an external 120W amplifier with PTT keying.
3. A 1296MHz DEM transverter with an internally mounted DEM 18W and T/R relay driving an external surplus Nortel 60W amplifier from KJ6KO.
4. A 903MHz DEM transverter with a 100W surplus cellular Motorola amplifier with a T/R relay.
5. 28MHz IF switching to the right transverter (144, 222, or 432MHz) or HF using the K2 and Elecraft transverter built in features.
6. 144MHz IF switching to the right transverter or amplifier and antenna connection, with T/R switching.
7. Front panel ¼" headphone jack.

Looking at the above list of requirements you can imagine the need for a bunch of switches to align all the right parts at the right time. I wanted to eliminate as much of these as possible. Manually hitting the right combination of manual switches to prevent missing a quick contest QSO on rapid band changes and to avoid equipment damage. I once tried to manually operate one or more switches in this setup – that did not last long. I then introduced the KRC2 band decoder to my station. Some of these requirements are unique to my station layout and VHF interests, but many aspects of this may apply to most anyone. A complete interconnect drawing is at the end of this document.

Band Selection and the K60XV

The K2 firmware (2.04P or newer) supports up to 6 transverter bands. Each band can store the direct frequency readout (first 3 digits, 0 to 999MHz), maximum power level in 2 ranges (high level 0-12.7 Watts or low level linear .01 to 1.27mW), IF frequency (I use 28MHz), a display correction offset to account for transverter LO frequency misalignments, and Transverter control address selection which plays an important role in my solution. The low power 1mW range is only available when the K60XV transverter interface option is installed.

The K2 and associated equipment are housed in a box made from oak plywood to match my desk. Small aluminum angle stock is used for shelf supports and aluminum sheet is used as the shelving. The small panel to the left of the speaker used to be the manual transverter switch – now it only supports the ¼" headphone jack connected to the external speaker circuit. Behind that panel and speaker is a 16W 1296MHz amplifier and power distribution box. The KRC2 is visible on the left side of the 80Watt 144MHz brick. The SMA IF switch is just above the KRC2 Band Decoder box and is mounted on a rear support.

28MHZ and transverter/HF selection

See the station drawing for reference to the cabling needs. I chose to use the Elecraft XV144, XV222, and XV432 transverters to ease the 28MHz switching needs and eliminate extra external relays and control wiring. These transverters offer internal relays that can be automatically selected by either the K2 aux bus commands, or a 12V enable signal. I use each method for reasons discussed later.

I use the K60XV 60M and transverter level interface to provide 60M coverage on HF, and to drive the VHF band transverters. It provides an adjustable 0.1-1mW level split path (TX/RX) output at 28MHz. The radio will automatically switch between the transverter output and the normal HF power amplifier and KAT2 outputs, so I have 3 possible HF signal connections to choose from. For HF I happen to have a 20M inverted vee on ANT 1

connector, and a remotely tuned long wire for all other HF bands on the ANT 2 connector. I daisy chain the 28MHz transverter outputs (RX and TX) with short RG-316 cables with SMA T connectors and BNC connectors.

144MHz and 144MHz IF Switching

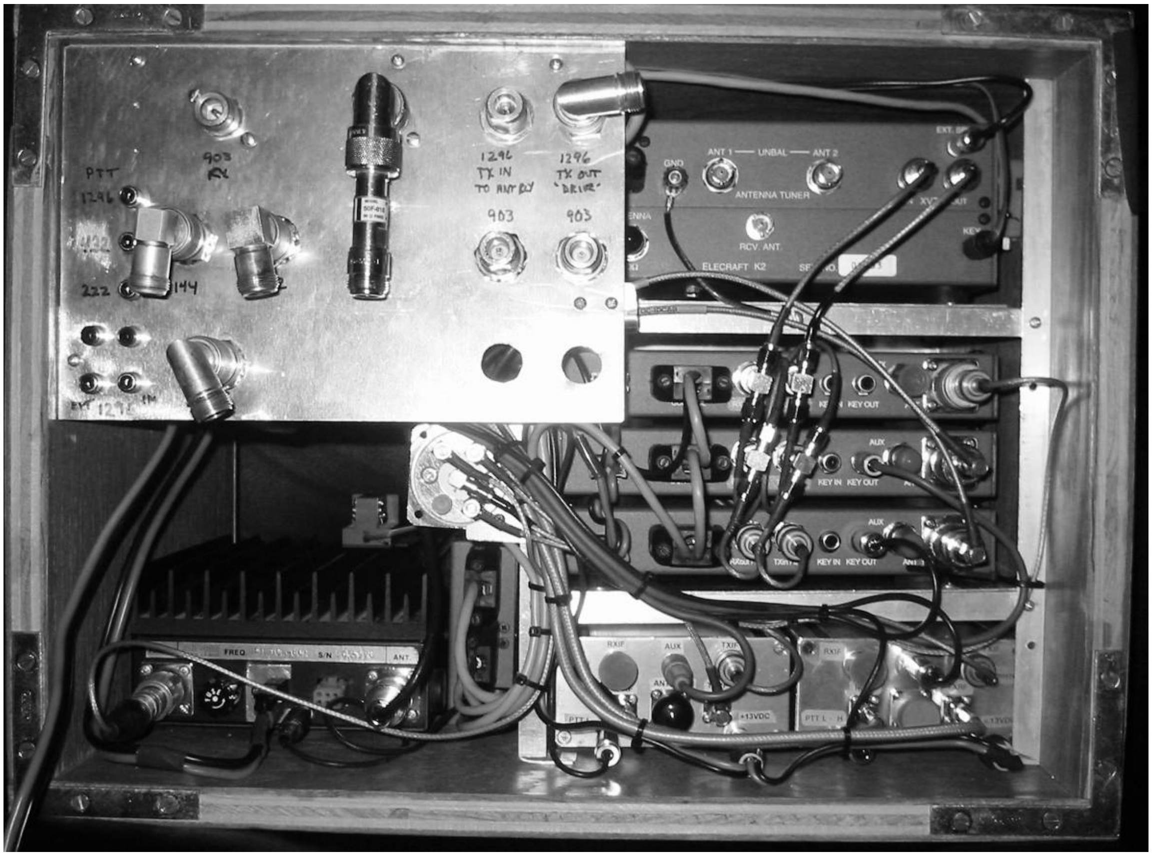
I use the 144MHz transverter output to drive the DEM transverters and also for direct 144MHz communications. Because I am using the 144MHz band in several different ways, things are a bit more complicated. You could just equip the K2 with an internal or external low level 28MHz to 144MHz transverter unit (~100mW), such as that available from DEM. Since I wanted to operate the K2 on 2M band directly and I only needed 10W for amplifier drive, I decided this was not the way to go for me.

For driving the microwave transverters I wanted to use a low level output to minimize signal leakage on 2M that might interfere with other adjacent 2M gear. All of my transverters can accept a drive level from 1mW to 10W. In the end I compromised and chose a max drive of 3W. This level was chosen to match the 20dB usable range of attenuation the K60XV can provide, and achieving my need for 10W output for 144MHz amplifier drive and lower power levels for the transverters and their downstream PAs. I use high quality well shielded Teflon cable to help reduce signal leakage, particularly on the 144MHz high output cables, where I tend to use double shielded silver braided RG-142. For each transverter band I can program in a lower limit such as 0.30mW and limit the resulting XV144 output on 2M to a lower level such as 1W. The trick to the setup is establishing a system wide power level plan for drive levels to eliminate external attenuators and needless switching.

To route the 144MHz output to each transverter I use one 12VDC SP4T coaxial SMA RF switch. Mine happen to be TTL controlled. To add a 50Mhz transverter later I can simply daisy chain the 28MHz IF.

KRC2 Band Decoder Configuration

Combined with the K2 firmware and K60XV features, adding the KRC2 band decoder gives you great flexibility to control equipment as you change to a new band. Here I describe the control wiring and modifications I made to achieve complete band switching using only the BAND + and BAND - buttons on the K2.



This view shows the complete rear wiring and the SP4T SMA RF switch used for 144MHz IF signal routing to the microwave transverters. Position 1 routes directly to the 144MHz brick amplifier in the lower left corner. The 28MHz Split IF daisy chain uses RG-316 SMA jumpers. T/R relays for 903 and 1296 are mounted on the reverse side of the bulkhead panel. For 903 and 1296, external amplifiers connect to the right pair of N connectors. When not used, a coax jumper is installed on these to route to the T/R relay directly. The 1296 RX connection in the top center has an attenuator inline to offset the tower mounted preamp gain in the home station.

For the XV222, XV432, and future XV50, I use the K2 aux bus control method and set their transverter address IDs to 4, 5, and 6. The reason for starting with 4 is to keep addresses 1, 2, and 3 free to use the 3 standard high and low side XVTR drivers in the KRC2. For the 144, 903, 1296MHz I needed to:

a. Switch the coaxial RF switches to route 144MHz to the right transverter
b. Route PTT signal to the right transverter or 2M 80W internal amplifier
c. Enable the XV144 when 144, 903, and 1296MHz bands are selected.

The K2 firmware I am using (2.04p) provides that each transverter band can be assigned to the same or different transverter address (ADDR). I configured my bands like this:

K2 Band	Freq	rF	IF	OFS	Out	Adr	Pwr Output	Xverter/Brick Pwr/ Amp Out
TRN1	144Mhz	144	28	-0.83	L1.21	trn1	10W	10W/80W/300W

TRN2	222MHz	222	28	-2.73	L1.25	trn4	12W	12W/120W
TRN3	432MHz	432	28	1.20	L1.25	trn5	12W	1mW/200W
TRN4	903MHz	903	28	-1.96	L0.24	trn2	2W	2W/100W
TRN5	1296MHz	296	28	-9.30	L0.46	trn3	2W	0.5W/16W/60W
TRN6	OFF							

Table 1

The default KRC2 high and low side output configuration is configured to respond as follows to control the 2M transverter and 2 DEM transverters:

Outputs	Adr value
XVTR1 and /XVTR1	trn1
XVTR2 and /XVTR2	trn2
XVTR3 and /XVTR3	trn3

Table 2

Using the KRC2 jumper W5 these outputs may be configured into a binary coded output. This would give you the ability to control an output for each of the 6 transverter bands, but requires that you build a decoder and driver (buffer) circuit. In my scenario, I was able to avoid that by choosing strategic Adr assignments, assigning the XV series transverters to the address 4 and higher.

In the Table 1 example above, I might assign an XV50 to address trn6 and to keep the displayed band order correct by slide up all the settings to the next higher transverter band slot so I would hit band up and see 50, then 144, 222, 432, 903, 1296 (296 on display) in that order. To add another microwave transverter I need to either switch to binary coded output and build a 3 line to 8 line decoder and buffer circuit into the KRC2, or new KRC2 programming software could be used to remap an unused HF band output to TRN4, 5 and 6 addresses Note the “trn” (lower case) ADR value– this can be confusing. ADR is a separate parameter sent on the aux bus and is assigned individually to each band “TRN” (upper case) and happens to display the same name. You can assign the same ADR value to multiple bands if needed.

I did not use aux bus addressing for the XV144. The KRC2 (firmware v1.2) currently responds to only the trn address, not the TRN band selected. By default when you want to share the same XV144 transverter among several microwave transverters, one and only one KRC2 output would be activated – trn1 in the example in Table 1 above. To work around this I set the XV144 ID DIP switch for “No K2” and instead use the KRC2 XVTR

high side outputs to enable the XV144 using its 12V control signal 12CTRL at the D-Sub connector pin 8. Disconnect the original 12VCTL signal from pin 8 in the connector cable at the XV144 only. Run a wire (I used RG174) from the KRC2 to the XV144 connector shell and attach it to pin 8. Make sure the 12VCTL signal from the K2 reaches all other XV transverters.

Transverter	***Transverter Band Select DIP Switch SW1***
XV144	No K2
XV222	trn4
XV432	trn5

Table 3

Inside the KRC2 I used a small piece of perf board and mounted some diodes from XVTR 1, 2, and 3 high-side drivers for a wired-OR circuit driving a circuit design borrowed from the K2's 8R/8T switching system - a 2N7000 switching on a 2N3906 to pass 12V from the KRC power supply to the XV144 12VCTL signal via a piece of RG-174. See the Figure 1 for more details. For the TTL controlled 144MHZ IF switching, I used the internal KRC2 5VDC power connected to J5 Vbb connector. The high side outputs drive the TTL switches and the Wired-OR diodes inputs. In my arrangement no external power was required for the KRC2 box. The K2 supplies the necessary power from its connecting cable at J2.

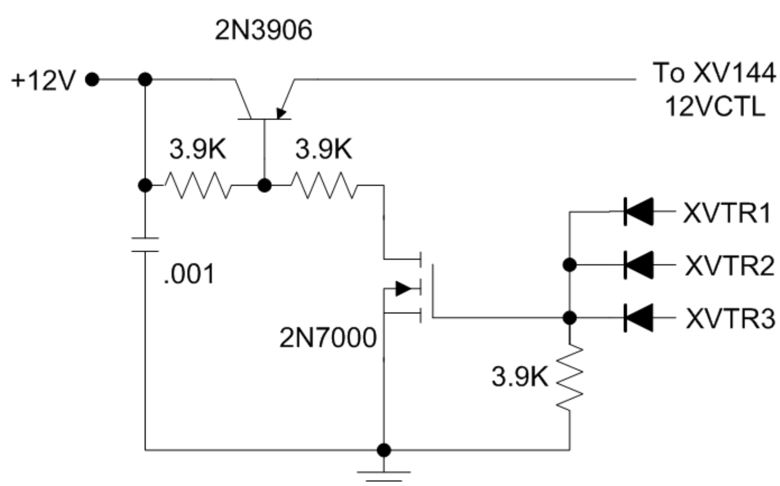


Figure 1

PTT Switching

For PTT routing I modified the KRC2 slightly to use the 8R signal on pin 9 of the KRC2 J2 connector to enable/disable the low side outputs /XVTR1, 2 and 3. This involves cutting free from ground pin 9 (/G) of each TPIC6595 driver chip (U6 and U7) and connecting to AN1 of the CPU (U1). Since I had already assembled my

KRC2 I used a very sharp fine pointed blade and carefully cut free the pin and bent it up parallel to the PC board. You want to be careful you do not break off the pin, or crack the casing materials around the IC pin while doing this. It is easiest to bend the pin out before assembly, or cut the pin 9 pad free of ground on both sides before installing the chip when building the KRC2. You cannot simply cut the ground trace from pin 9 PCB pad after installation because there is a ground connection under the chip from pin 9 that is not visible or accessible once assembled.

I tapped the AN1 signal at the junction of R6 and R10. Signal 8R from the K2 supplies 8V on RX for 4 to 5 volts at AN1, and no voltage on TX. In TX mode R10 and other resistors pull down AN1 (now the same as /G) to ground so it enables the U6 and U7 outputs. In RX mode the 4 volts at /G disables the U6 and U7 outputs. My equipment needs a solid ground for TX PTT so this works fine.

T/R Relay Switching

I happen to have several 12VDC coaxial high and medium power T/R relays with N connectors. My 903Mhz, and 1296MHz RF outputs are split path to simplify connecting high power amplifiers with the fewest relays for the lowest loss and highest reliability. The SP4T SMA switch is a latching type reducing power drain. The KRC2 low side outputs are wired to the 2M 80W PA and the 2 DEM transverters PTT inputs, and I use the aux relay outputs on the DEM transverters to supply +12VDC on TX to turn on the amplifier output T/R relays. These relays are mounted right at the output of the amplifiers. The K2 has configurable T/R switchover and RF TX delays to help simplify sequence timing.

For the 144MHz 80W amplifier I modified a Mirage B108 replacing the 3 pin power connector with a Power Pole connector and added one RCA phone jack for PTT switching. The PTT jack on the back of each XV transverter is free to connect to the optional external amplifiers.

Antenna Connections

Reaching into a box amongst many cables and tight spacing make quick relocation of the portable station difficult. I chose to build a bulkhead panel using a piece of aluminum sheet and mounting N chassis connectors for most all bands except the 2 K2 BNC HF jacks, which were easy to access. Placing the station on my desk at home it sits close up to a wall so I use high quality Teflon right angle N connectors so the ½” coax cables route down and away to the floor. When the station is in my truck, it is normally positioned in the passenger seat

facing me, and the K2 is mounted on the left upper side so it is easy to control and see over the armrest. A microphone holder is on the top left side.

HF Use

Since I am using the K60XV transverter interface for my IF output, this frees up the HF outputs at the back of the K2. Each HF and transverter band automatically selects the KAT2 antenna connector or transverter IO connector as appropriate, no extra relays required and no high power 28MHz IF leakage to worry about going to an HF antenna. For quick QRP HF outings, I can quickly disconnect the cables at the back of the K2 and slide the K2 out of the box and use it as a stock rig in less than 1 minute. All the original K2 features are preserved. I might choose to add a KPA100 amp someday, and would probably choose the internal arrangement to maintain compactness and switch the lids if QRP was needed. I would need to drill holes and relocate my IF outputs to the lower back panel (or get a replacement panel with the holes available from Elecraft).

My web site at http://mysite.verizon.net/michael_d_lewis/index.html has more information and pictures which may be updated from time to time.

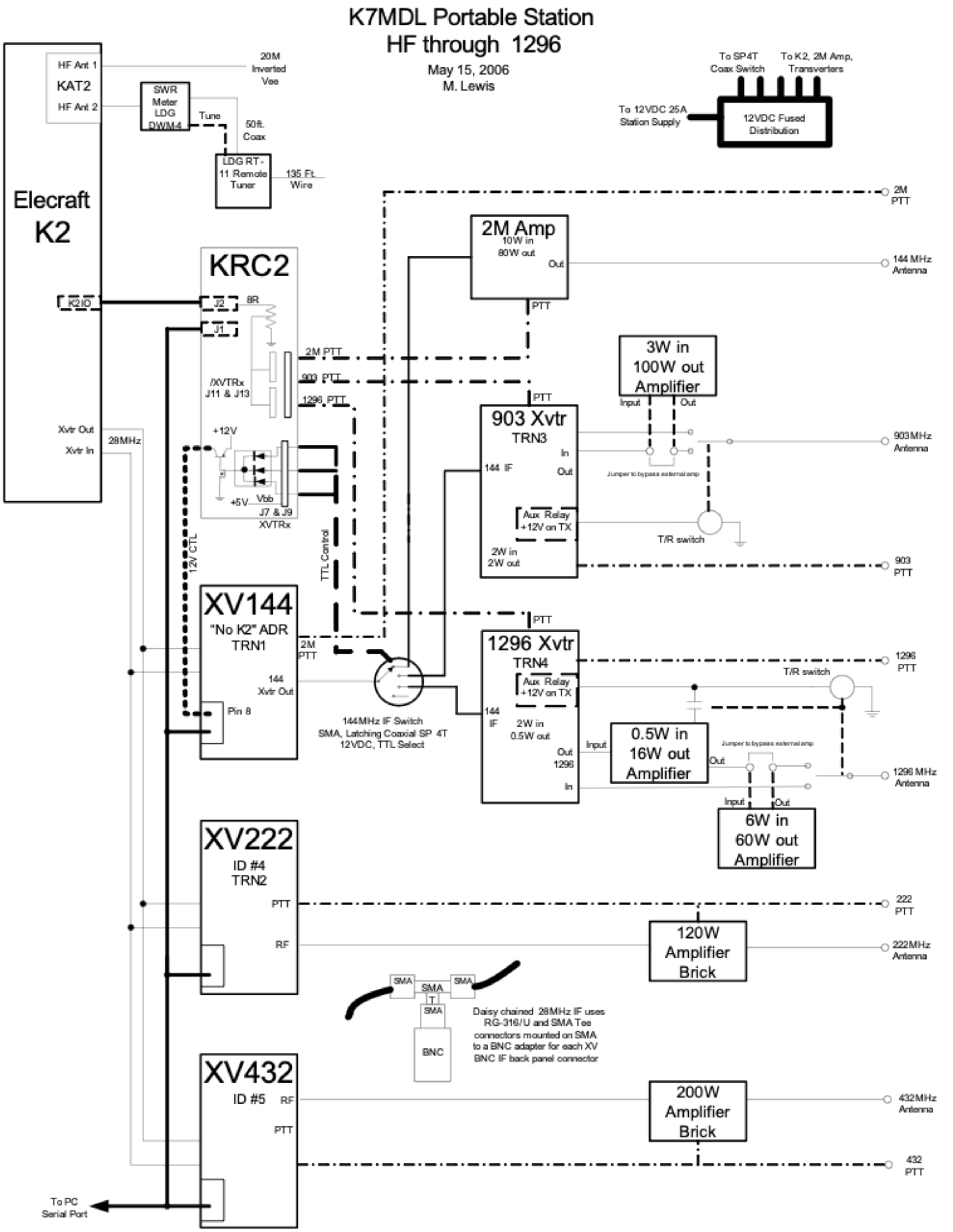

K7MDL Portable Station
HF through 1296
May 15, 2006
M. Lewis
To SP4T Coax Switch
To K2, 2M Amp, Transverters
To 12VDC 25A Station Supply
12VDC Fused Distribution
Elecraft K2
HF Ant 1
KAT2
HF Ant 2
20M Inverted Vee
SWR Meter LDG DWM4
Tune
50ft. Coax
LDG RT-11 Remote Tuner
135 Ft. Wire
K2IO
Xvtr Out
Xvtr In
28MHz
KRC2
J2
J1
8R
2M PTT
903 PTT
1296 PTT
/XVTRx J11 & J13
+12V
+5V
Vbb
J7 & J9 XVTRx
12V CTL
TTL Control
2M PTT
2M Amp
10W in 80W out
Out
PTT
144 MHz Antenna
3W in 100W out Amplifier
Input
Out
PTT
903 Xvtr
TRN3
In
Out
144 IF
Jumper to bypass external amp
903MHz Antenna
Aux Relay +12V on TX
T/R switch
2W in 2W out
903 PTT
XV144
"No K2" ADR
TRN1
2M PTT
144 Xvtr Out
Pin 8
144MHz IF Switch
SMA, Latching Coaxial SP 4T
12VDC, TTL Select
PTT
1296 Xvtr
TRN4
1296 PTT
T/R switch
Aux Relay +12V on TX
144 IF
2W in 0.5W out
Out 1296
In
Input
0.5W in 16W out Amplifier
Jumper to bypass external amp
Out
1296 MHz Antenna
Input
Out
6W in 60W out Amplifier
XV222
ID #4
TRN2
PTT
RF
222 PTT
120W Amplifier Brick
222MHz Antenna
SMA
SMA
SMA
T
SMA
BNC
Daisy chained 28MHz IF uses RG-316/U and SMA Tee connectors mounted on SMA to a BNC adapter for each XV BNC IF back panel connector
XV432
ID #5
RF
PTT
200W Amplifier Brick
432MHz Antenna
432 PTT
To PC Serial Port

Figure 2